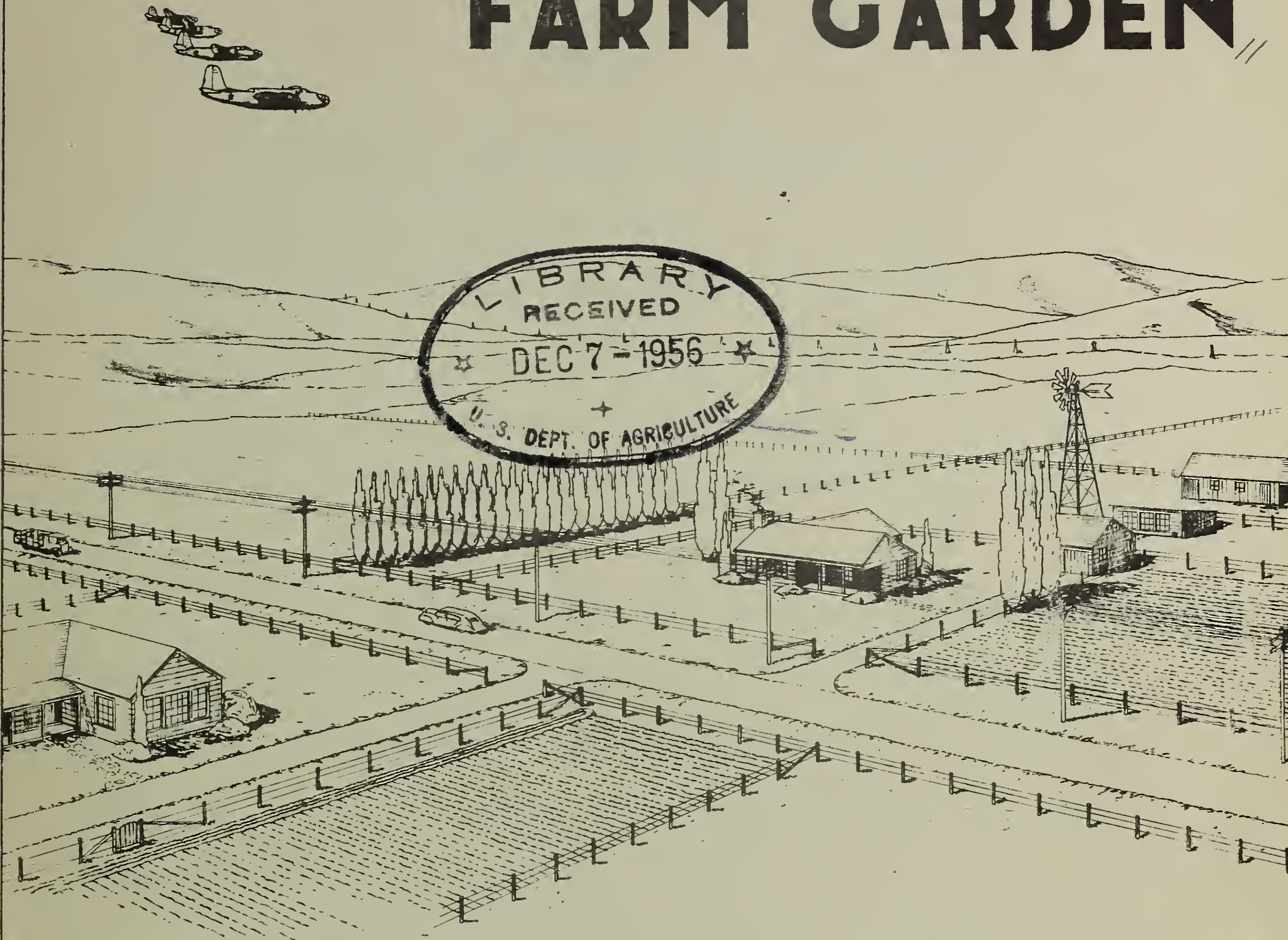
3

IRRIGATION OF THE FARM GARDEN



UNITED STATES
DEPARTMENT OF AGRICULTURE
U.S. FARM SECURITY ADMINISTRATION

food will win the war and write the peace" — Sec. Wickard.

OFFICE OF CHIEF ENGINEER

DISTRICT VII

DENVER, COLORADO

JANUARY 1943

FOOD FOR FREEDOM

FOREWORD

Secretary of Agriculture, Mr. Claude Wickard, recently said "food will win the war and write the peace". Our armed forces will need a considerable portion of the canned fruits and vegetables during the coming months until victory. It would seem to be the patriotic duty of each citizen to raise a vegetable garden where the means are at hand to do it.

It is the aim of this circular to describe some simple means of irrigating the vegetable garden to insure maximum yields in those portions of the west where rainfall is insufficient. The various means of irrigation described have been tried and found to be successful during the recent years of drouth. The author is indebted to many farm families for the ideas incorporated herein and to many persons connected with the United States Department of Agriculture for the further development of these ideas.

INDEX

IRRIGATION OF THE FARM GARDEN

by

Ivan D. Wood, District Engineer

Illustrations by Howard Moore, Junior Architect

I Introduction

In much of the Great Plains and Inter-mountain areas of the United States, supplemental water must be used for growing vegetable gardens. Practically all vegetables contain from 85 to 90 per cent of water, and good yields as well as good quality are dependent upon a moisture supply which will mature the crop at the optimum rate. Some vegetables may survive a prolonged drouth period but are liable to do so at the expense of both quality and yield.

Water stored in the subsoil during the fall and winter may have considerable influence on the amount of supplemental water needed during the next growing season. High temperatures and high wind velocities increase evaporation and the amount of water needed by plants.

II Water Requirements of Vegetable Crops

The water requirement of garden crops varies greatly due to climate, soils, topography and other factors. In the eastern part of the states comprising Region VII, namely, North and South Dakota, Nebraska and Kansas, 12 inches of irrigation water applied during the growing season in addition to rainfall ordinarily will assure garden crops. In western portions of these states and in Montana, Wyoming and Colorado from 20 to 36 inches of supplemental water may be required. The following points are important in the irrigation of vegetables.

1. Adequate moisture in the top 12 inches of soil is essential to the growth of lettuce, radishes, onions, peppers and spinach.

2. Adequate moisture in the top 24 inches is necessary for deeper rooted varieties as beets, carrots, parsnips, potatoes, sweet potatoes, peas, beans, etc.

3. Sweet corn, tomatoes, cucumbers and melons are capable of drawing moisture from depths of 3 feet or more.

4. An inch to an inch and one-half of water in the form of irrigation or rain must be applied every five to seven days in hot weather if optimum growing conditions are to be maintained.

III Sources of Water Supply

1. Quality of Water.

In some sections well water and that from streams is unfit for irrigation purposes due to the presence of alkali salts. When water containing alkali begins to evaporate from the soil surface it increases the concentration of salt in the soil to such an extent that plants may assume a yellowish brown appearance and fail to develop properly or may die before

maturity, thus sharply decreasing yields. Streams that are suitable for use during flood stage may contain harmful concentrations of salts when at low water stage.

In general irrigation water must not contain over 2000 parts per million total salts and not over 50 per cent of the salt content can be sodium salts. Even though the total content is as low as 500 parts per million not over 50 per cent should be sodium salts.

Many states maintain a free testing service through the State Health Department or the Agricultural College. Unless water supplies are known to be free from harmful ingredients such tests should be made before much time and effort are spent in attempting garden irrigation.

2. The Farm Well.

The usual rate of flow from the farm well is from 2 to 5 gallons per minute. Experience has shown that from 3000 to 5000 gallons may be pumped per week for garden irrigation in addition to household and livestock needs. This amount will provide a one inch application to from 1/10 to 1/5 acre of ground.

1/5 acre is a strip of ground approximately
90 x 100 feet
1/10 acre is a strip of ground approximately
45 x 100 feet

More satisfactory results will usually be had with the use of the farm well if some sort of storage is provided. In this way a supply can be accumulated and applied quickly during the evening when less loss will be occasioned by evaporation. An old stock watering tank 10 feet in diameter and 2 feet deep will hold nearly 1200 gallons, or enough to water a strip of garden 18 feet wide and 100 feet long with 1 inch of water. See Figure 1. A group of old oil barrels connected with pipe nipples will serve fairly well, but reservoirs of earth are not to be recommended when using limited water supplies because of heavy seepage and evaporation losses.

One problem always encountered in the use of the farm well for garden irrigation is that of conveying water to the garden. It is sometimes possible to obtain black pipe 1 inch in diameter for 5 to 6 cents per lineal foot or an economical "V" shaped trough can be made of 1 x 4 inch lumber and painted for about $4.00 per 100 lineal feet.

Water can be pumped directly into lister rows during the fall months to build up a moisture supply in the subsoil to a depth of 3 feet for use during the following year. This reserve supply may greatly lessen the amount of irrigation required during the growing season.

3. The Small Irrigation Well.

In many places along river valleys, where the water table is permanently within 10 feet or less from the ground surface, small irrigation wells can be installed profitably for garden irrigation. The casings used are generally from 6 to 12 inches in diameter and may be of galvanized iron, concrete or wooden staves. One popular type of home-made casing consists of old range boilers with the ends cut out welded together to form a tube 12 inches in diameter. Water enters through slots approximately 1/8 inch wide and from 6 to 8 inches long cut with a welding torch. The casing is sunk to a considerable depth below the water table by means of a sand bucket. Wells of this type have been known to yield from 50 to 200 gallons per minute. As shown in Figure 2, a small horizontal centrifugal pump is set at the ground surface and operated by a gasoline engine or an electric motor if power is available. Small direct connected electrically or engine operated pumping units are usually more efficient than belted ones and are more easily set up for operation. Horse power and fuel requirements are given in the appendix.

4. Streams, Lakes and Ponds.

The same type of horizontal pump described in connection with the small irrigation well may be placed on the bank of a stream or pond and used to deliver water to a garden plot on higher ground. See Figure 2. Ordinarily the pump should not be set higher than 10 feet above the water surface and the pipe used for suction and discharge should be at least 1 inch larger than the size of the pump. In some instances old threshing machine water wagon pumps have been ingeniously rigged up for engine operation to deliver irrigation water to a farm garden.

The hydraulic ram which operates from a flow of water in a drive pipe and delivers a small quantity to a higher level, may be used in connection with springs, artesian wells or clear streams which are relatively free from floods. Such a device has the advantages of low cost, continuous operation and may be depended upon for long and reliable service. Several applications of the hydraulic ram are shown in Figure 3.

A dependable supply of water for the farm garden often may be had by placing a dam across a ravine to form a pond. In some locations soil conditions are such that portions of the valley floor below the dam are sub-irrigated and are suitable for vegetable production. Also at the time of construction, it may be possible to place a pipe 2 inches or more in diameter provided with a shut off valve through the dam to permit garden irrigation on lower ground. See Figure 4. It is essential that the upstream end of the pipe be protected from becoming clogged with trash as shown. Help in the location and planning of the earth dam and emergency spillway often may be

had from the State Agricultural College, the local Soil Conservation District Office, the local County Extension Agent, or the F.S.A. County Supervisor.

5. Diversion of Run-Off Water.

A considerable portion of rainfall in arid and semi-arid regions comes in showers of from 1/4 to 1/2 inch which are not effective in replenishing soil moisture because of heavy evaporation and run-off losses. If this run-off from fields or pastures can be diverted to the garden plot, beneficial results can be obtained. As shown in Figure 5, it may be directed by means of a ditch or contour furrow to a small reservoir made by plowing several furrows together to form a levee or embankment at the upper end of the garden plot. The dirt in the embankment should be packed by tamping when in a moist condition. It is necessary to have the levee at the same elevation at all points to prevent breakovers and at one point an overflow box should be provided.

On the side next to the garden a small head ditch is constructed and water is conducted to it from the reservoir through a take-out box. From the head ditch water is supplied to each row of vegetables through small pipes set in the bank of the head ditch.

Since the small reservoir is subject to heavy losses by seepage and evaporation, no attempt should be made to store water for periods of more than a few hours. Better results will be had if the water is used immediately.

In many cases it is possible to divert part of the run-off flow from a ravine to a potato patch or garden plot. Many examples have been noted where farmers have located gardens on small terraces above the flood waters and then diverted a part of the flow to a small reservoir as has been described, from which it could be used on a garden. The same arrangement can be used to store water in the subsoil during fall, winter and early spring months. See Figure 6.

6. Conservation of Moisture from Snow and Rainfall.

A. Surface Treatment.

Silt loam soils will hold as much as 2 inches of moisture per foot available to plants. Six inches of moisture stored in the top 3 feet of soil in addition to that which is added as percipitation and supplemental irrigation may be a great factor in the production of a vegetable garden.

After the last crop has been removed in the late summer months one or more moisture conserving practices may be followed. Lister furrows dammed with a shovel at 5 to 10 foot intervals often prove beneficial in conserving water from fall rains and in holding snow where it falls. A trash or straw

mulch is beneficial in preventing evaporation from the ground surface and in preventing run-off. There is a decided advantage in using a straw mulch during the growing season on long-season crops as tomatoes, potatoes and various kinds of vine crops but it is not ordinarily recommended for short-season crops as radishes, lettuce, etc. With the exception of potatoes, mulches should not be applied until the crop is well established.

B. Snow Traps and Snow Ridging.

Replenishment of soil moisture by snow in the garden plot is often lost because of drifting in places where little benefit results. Ordinarily a 10 inch snowfall equals one inch of rainfall, but it has been shown that as much as 4 inches of moisture per foot of snow depth can be obtained from packed drifts. In some observations made in North Dakota it was shown that as much as 16 inches of moisture was stored in the soil of the garden plot from the melting snow drifts.

Often the garden can be located on the side of windbreaks opposite the direction of prevailing winter winds where snow is known to drift or drifting can be encouraged by the use of slat, snow fence or by tying cane or corn bundles in the garden fence as shown in Figure 1. Cane, corn or sorghum in the form of bundles tied in the garden fence or planted thickly around the garden will afford considerable protection from hot winds. Permanent planting of hedge or shrubs for this purpose is to be encouraged.

C. Summer Fallow Methods.

In those regions where summer fallow methods are practiced for field crops, there is reason to believe that the same practices will be successful in building up a deep soil moisture supply for long-season garden crops. The ground surface should be kept clean cultivated as well as rough and cloddy to encourage more rapid penetration of rainfall. A straw mulch cover will both increase penetration and decrease evaporation.

IV <u>Location of Garden</u>

1. Soils.

For gardening purposes fine sandy loam soils produce satisfactory yields of more varieties of garden vegetables and fruits than any other texture of soils. In addition, sandy soils use water which falls in the form of rain more efficiently since there is generally less run-off and surface evaporation. While there is often little choice as to soils, if the garden plot is located where it can be irrigated, heavy clay, alkali or loose sandy soils should be avoided if possible. Where it is necessary to use loose sandy soils, heavy applications of manure and about double the average frequency of irrigation usually will allow the production of a satisfactory garden.

Heavy clay soils will also produce satisfactory yields of most vegetables except melons and potatoes if heavy applications of manure are worked into the upper 8 to 12 inches of the soil each spring.

When the garden plot is left in the same location year after year the addition of fertilizers in the form of well rotted barnyard manure may be necessary. It is important that the manure be applied on that portion of the garden planted to the deeper rooted crops as beets, potatoes, carrots, etc., and that it be worked thoroughly into the soil. Applications which are too heavy are liable to cause burning unless a great deal of water is applied.

That portion of the garden on which manure has been applied may be planted to the shallow rooted crops such as lettuce, radishes, etc., the next year. This type of rotation will insure high fertility in all parts of the garden plot.

2. Slope and Convenience to Water Supply.

Row directions should be down the greatest slope for best results in the garden irrigation. Rows running across the slope or on the contour are not so satisfactory since the stream is liable to break from one row to another unless the slope is less than 6 inches per 100 feet. Slopes in excess of 2 to 3 feet per 100 feet may prove difficult unless very small streams of water are used in each row.

Convenience to the well, or other source of supply may be the controlling factor so far as location is concerned.

V Application of Irrigation Water

The rate at which irrigation water should be applied to the garden as well as the methods of application will vary depending upon the type of soil, the slope and the head of water available. In sandy soils considerable water must be turned into each row since the absorption rate is high and a small stream would benefit only the upper portion of each row. The distance which water is carried in each row is also important. In sandy soils the rows should be short to prevent over irrigation in the upper portion of each row. In far too many cases crops have been ruined or yields seriously impaired by not applying irrigation water soon enough.

A moist seed bed is needed in which to plant garden seeds. If the soil is dry the area to be planted should be irrigated, and when dry enough, the seeds planted. Often the irrigation water is run down the furrows placed where the rows of vegetable crops are to be planted. When dry enough to plant, these furrows should be cultivated, as by a rake, and the seed planted in pulverized moist soil. It is seldom recommended to plant the crop and then irrigate as the soil will crust and bake, thus smothering many seedlings.

1. Storage is Advised.

When the farm well or other irregular sources of supply delivering small flows are used for garden irrigation, some type of storage is necessary for best results. Often an old stock watering tank can be repaired and used. Old engine boilers, barrels connected with pipe and tight earth reservoirs have all served the purpose.

The stored supply can be applied more effectively in the evening when evaporation losses are less and when more attention can be given in securing even distribution.

2. Furrow Irrigation.

Most garden crops can be effectively irrigated by using small furrows made between rows with the point of a hoe or other garden tool. Where rows are wide apart as is often the case with farm gardens which are cultivated with horse drawn machinery, the irrigation furrow should be made near the growing plants. The supply ditch from which water is taken may be a plow furrow or lister row from which the loose dirt has been removed with a shovel. For best results, water from a supply ditch should first enter a secondary ditch or regulation bay through a take-out box as shown in Figure 7. From the secondary ditch, each small furrow may be served through small tubes made from 1/2 inch pipe, garden hose or lath, set in the ditch bank. By regulating the flow through the take-out box the amount of water distributed to each row can be adjusted accurately to meet conditions. The distance which water should be allowed to run in a row will vary from 50 to 200 feet, depending on soil type and condition as well as the slope. If it is necessary to raise the level of water in the head ditch, it may be accomplished by the use of a metal or canvas dam as shown in Figure 7. After the water has been started, frequent examinations of the subsoil should be made to determine if moisture is percolating to a uniform depth in all parts of the land being irrigated.

3. Furrow Irrigation with Limited Water Supply.

When the water supply is very limited as is the case with the ordinary farm well, water should not be wasted in distribution ditches but should be carried directly to the place of application in pipe, hose, or trough made of 1 x 4 inch wood, painted or creosoted to prevent early decay. Figure 1 shows water being delivered from a stock watering tank through pipe to a wooden trough from 6 to 10 feet long provided with tin or galvanized spouts from 1/4 to 3/8 inch in diameter, spaced to correspond to the width between rows. The trough allows uniform distribution and may be carried around from place to place as irrigation progresses. If some of the spouts are not needed they may be plugged with corn cobs or corks.

4. Use of Porous Canvas Hose.

Hose from 2-3/4 to 3-1/2 inches in diameter made from strips of 10 to 12 ounce canvas is convenient for watering plants which have been mulched or for vines or bushes which cover the ground heavily. If canvas cannot be obtained denim may be used. This method can be used for row crops on sandy land where percolation losses would be too great in furrow irrigation. Water is ordinarily carried to the canvas hose through pipes from a pump or storage tank. Seepage takes place through the pores of the fabric to saturate the soil beneath. The hose is moved about from place to place as the needed moisture is supplied.

Canvas may be purchased in 36 inch widths and cut into four 9 inch strips each of which is sewed with a flat seam to form the hose. To join one length to another it is necessary to insert one piece into the other after which the outward pressure of water will hold them together.

The life of the hose can be greatly increased if it is picked up from the ground and dried after being used. With careful treatment it should last from 4 to 5 years. With ordinary sources of supply as a farm well, 30 to 40 feet of porous hose should prove sufficient. See Figure 8.

5. Sprinkler Systems.

Sprinkler systems have only a limited application on farms because of the expense involved and because water must be delivered to the sprinkler under considerable pressure. The system has the disadvantage of heavy evaporation losses also. Many garden crops should not be sprinkled in hot dry weather.

6. Subsoil Irrigation.

A great deal has been said and written about subsoil irrigation by means of tile, tin cans laid end to end and by wooden tubes made of lath. Actual field experience as well as experimental work does not lend a great deal of encouragement to its use except under rather unusual soil conditions.

The tubes are laid from 6 to 8 inches deep for small crops and up to 12 or 18 inches for deeper growing varieties. In most deep soils of the west the water from the buried tube or tile has a tendency to saturate to a depth far below the root zone of ordinary garden crops. Contrary to what one might think, this saturated zone is very narrow as shown in Figure 9. If a heavy, impervious subsoil is present 18 to 24 inches beneath the surface, conditions are more favorable for the use of subsoil irrigation since the heavy layer will stop the downward flow and cause a wider saturated zone.

Under the most favorable conditions there is little to be gained by the use of an underground irrigation system. If it is attempted, the use of tubes made of lath is recommended instead of tin cans which rust away immediately. Holes 1/8 inch in diameter along the sides of the lath tubes permit water to enter the soil.

7. Direct Application.

Where no irrigation facilities of any type are available, it may be possible to grow good quantities of certain crops. Many families grow good tomatoes by placing a gallon syrup pail, perforated with a small nail hole, near each plant as shown in Figure 9. The pail is filled by carrying water from a well two or three times a week. The water from the pail percolates slowly into the ground, very little being lost by run-off or evaporation. A few vines cared for in this way were found to produce more fruit than several times as many grown under dry land conditions.

VI Vegetable Varieties

The selection of vegetable, fruit, and berry varieties for the locality as adapted to irrigation is important in order to secure the best results from an irrigated garden. Information on adapted varieties, planting dates, spacing and other facts may be obtained from the local County Extension Agent or from the Agricultural Experiment Station in your state. This information is free for the asking.

SUMMARY

1. Vegetables contain from 85 to 90 per cent of water. Good yields as well as good quality are dependent upon a moisture supply which will mature the crop at the optimum rate.

2. Adequate moisture in the top 12 inches of soil is essential for growing of lettuce, radishes, onions, peppers and spinach. Deeper rooted crops as beets, carrots, parsnips, potatoes, sweet potatoes, peas and beans require adequate moisture in the top 24 inches of soil.

3. Water from wells and streams may not be suitable for irrigation purposes due to the presence of alkali salts. If doubt exists regarding the quality of water supply, a sample should be sent to the State Health Department or the Agricultural College.

4. The ordinary farm well yielding from two to five gallons of water per minute may be used to irrigate a garden if storage is provided. An old stock watering tank 2 feet deep and 10 feet in diameter will hold nearly 1200 gallons, or enough to put one inch of water on a strip of garden 18 feet wide and 100 feet long. See Figure 1.

5. Along river valleys where the water table is permanently within 10 feet or less from the ground surface, small irrigation wells may be profitably installed for garden irrigation. Small, engine driven centrifugal pumps and home-made well casings are commonly used. See Figure 2.

6. Small engine driven centrifugal pumps set not higher than 10 feet above the water of streams or ponds often provide a dependable supply for the garden. See Figure 2.

7. By placing an earth dam across a ravine to impound water, a supply for garden irrigation may be developed, as shown in Figure 4.

8. In arid and semi-arid regions, a considerable portion of the rainfall comes in showers of from 1/4 to 1/2 inch, which are not effective in replenishing soil moisture due to rapid evaporation and run-off.

9. Run-off water for irrigation may be directed to a small reservoir by means of a contour furrow as shown in Figure 5. It is sometimes possible to divert a part of the run-off flow from a ravine to a potato patch or garden plot as shown in Figure 6.

9. Garden soils may hold as much as 2 inches of water available to plants per foot of depth. This moisture in addition to rainfall and supplemental irrigation may be a great factor in vegetable production. Some of the ways by which moisture may be stored in soil are:

   (a) Listing garden plot in fall and damming these lister furrows with a shovel to conserve rainfall and water from melting snow.

   (b) Use of straw mulches on long season crop to prevent evaporation and run-off.

(c) Use of snow fence, or windbreak to encourage drifting of snow on garden plot.

(d) Use of summer fallow methods to conserve moisture stored in ground in one season for use the following year.

10. Fine sandy loam soils are best suited for growing of most vegetable varieties. Alkali or heavy clay soils should be avoided. Fertilizer in the form of well rotted manure may be added to that portion of the garden where deep rooted crops are grown.

11. For satisfactory irrigation, row directions should be down the steepest slopes. Slopes in excess of 2 to 3 feet per 100 feet may prove difficult to irrigate unless very small streams of water are used in each row.

12. Most garden crops can be effectively irrigated by using small furrows between rows through which water is allowed to run in small streams. The regulation of water and distribution to garden crops is accomplished by means of simple equipment as shown in Figure 7.

13. When furrow irrigation must be accomplished with very limited water supply as from a farm well, water should not be wasted in ditches but should be carried directly to point of application in pipe, hose or wooden troughs. A convenient method of distribution is shown in Figure 1.

14. Hose made from canvas or denim through which water will percolate under pressure is convenient for watering vegetables on rough or sandy land; or where straw mulches are used. The hose is moved about from place to place as moisture is needed. See Figure 8.

15. Subsoil irrigation by means of tile, perforated pipe, tin cans, etc., is not very successful except under conditions where a heavy soil layer is present from 18 to 24 inches below the surface. See Figure 9.

16. The selection of vegetable, fruit and berry varieties adapted to irrigation and to the region where they are to be grown is important. Such information can usually be obtained from the County Extension Agent or Rural Rehabilitation Supervisor in the local county.

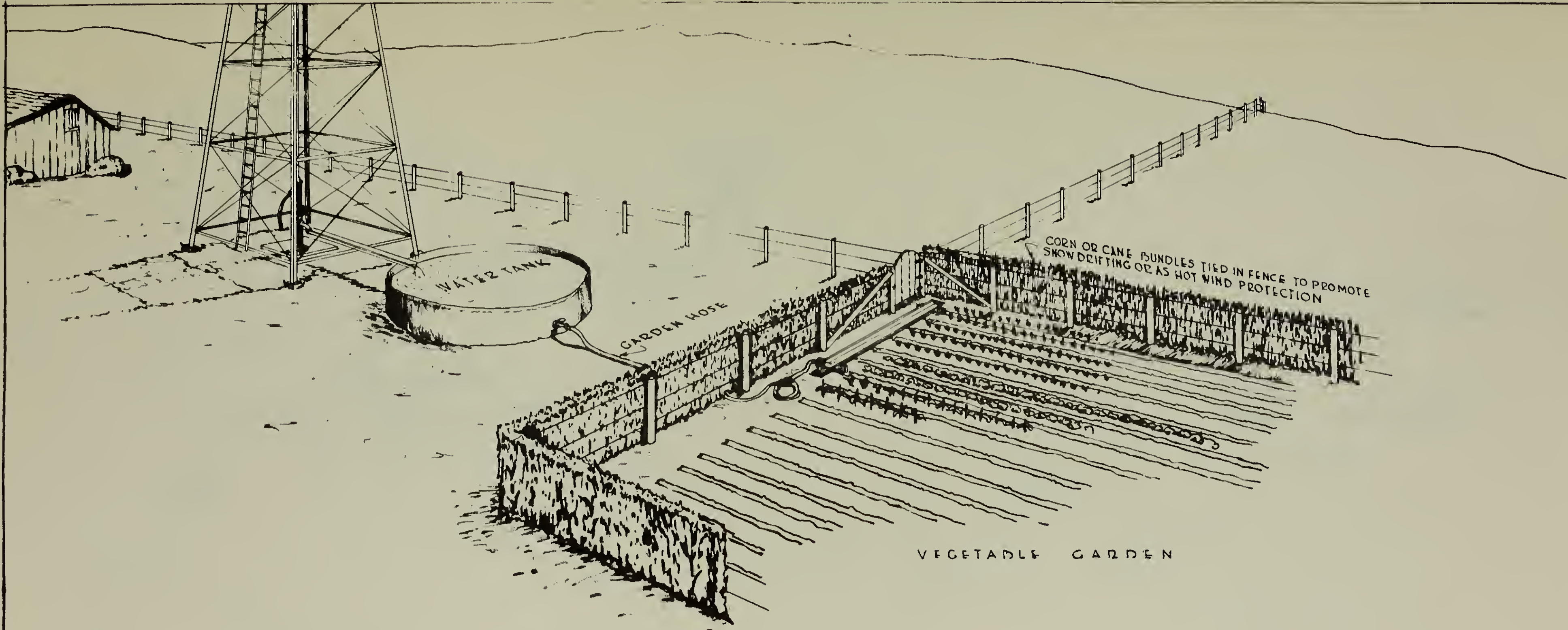
* * * * * * * * * *

APPENDIX

Horizontal centrifugal pumps are rated by the size of the discharge pipe. The ratings of pumps made by different manufacturers vary widely in speed, discharge and other factors. The rating data for the particular pump must be carefully considered. Information of a general nature regarding small sized centrifugal pumps is given below:

Size Discharge	Discharge in Gal. per min.	Speed in Revs. per min.	Approximate Suitable Acreage	Approximate Horsepower
3/4 inch	5 to 25	500 to 2350	Up to 1/3	1/4 to 1-1/2
1 inch	10 to 60	500 to 2350	Up to 1/2	1/4 to 2
1-1/2 inch	20 to 125	500 to 2350	1/2 to 1-1/2	3/4 to 3
2 inch	30 to 200	520 to 2000	1 to 3	1 to 5

* * * * * * * * * *

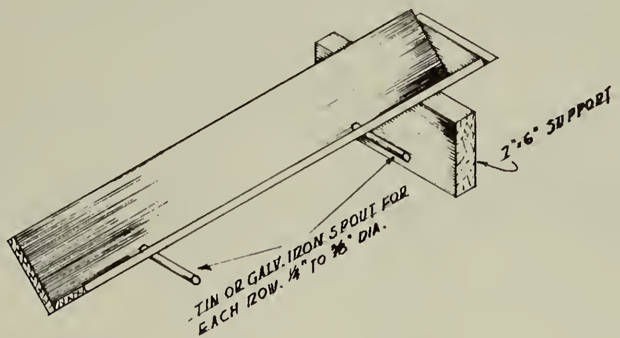


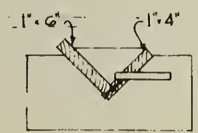
"A" GARDEN IRRIGATION FROM WINDMILL AND PUMP

THE ORDINARY FARM WELL OFTEN WILL PROVIDE A LIMITED WATER SUPPLY FOR IRRIGATION IF SOME STORAGE IS AVAILABLE. A WATER TANK 2 FEET DEEP AND 10 FEET IN DIAMETER WILL HOLD NEARLY 1200 GALLONS OR ENOUGH TO PUT ONE INCH OF WATER ON A STRIP OF GARDEN 18 FEET WIDE AND 100 FEET LONG.

TO AVOID WASTE WITH A LIMITED SUPPLY, WATER SHOULD BE CONDUCTED TO THE POINT OF USE THRU PIPES, HOSE OR TROUGHS. DISTRIBUTION TO EACH ROW IS MADE BY USE OF A 6 OR 8 FOOT LENGTH OF TROUGH FITTED WITH SMALL METAL SPOUTS SPACED TO FIT THE WIDTH OF GARDEN ROWS. THE TROUGH CAN BE CARRIED FROM PLACE TO PLACE TO AVOID RUNNING WATER TOO FAR IN THE ROWS.

THE USE OF CORN OR CANE BUNDLES TIED IN THE GARDEN FENCE ENCOURAGES THE DRIFTING OF SNOW IN THE WINTER TIME TO CONSERVE MOISTURE AND PROTECTS VEGETABLES FROM HOT WINDS IN SUMMER.

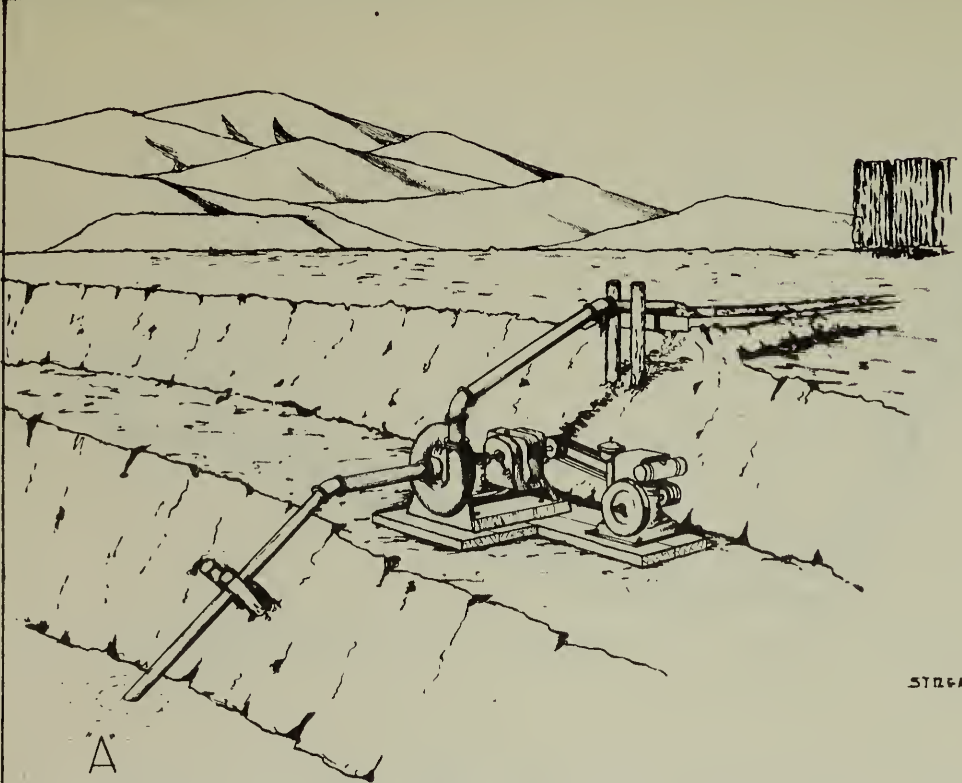




"B" TROUGH DETAILS

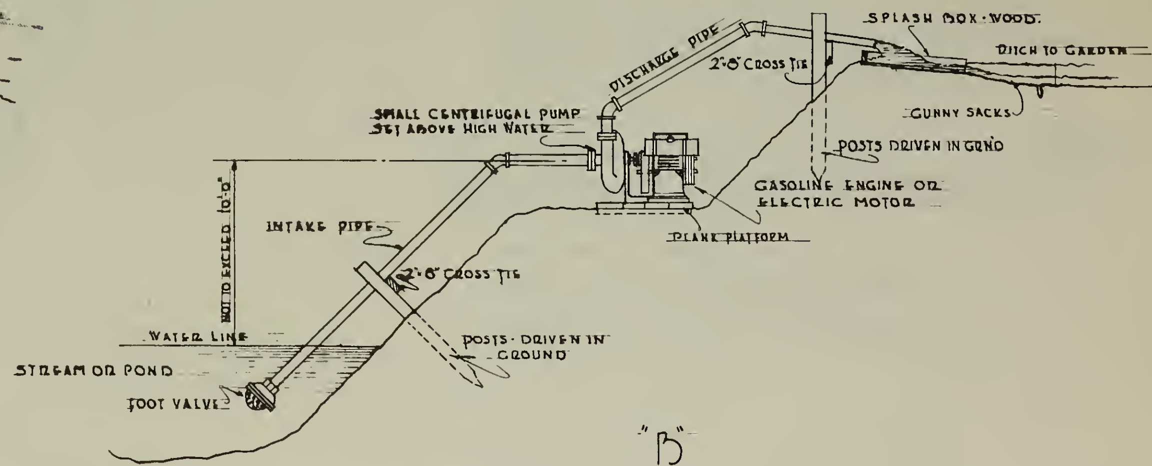
FIG. 1.

USDA	FARM SECURITY ADMINISTRATION		USDA
DENVER COLORADO	IRRIGATION STRUCTURES		F. 313-14 D. 12/22/42
Des. WOOD	Dr. MOORE	Tr. MOORE	Ck.



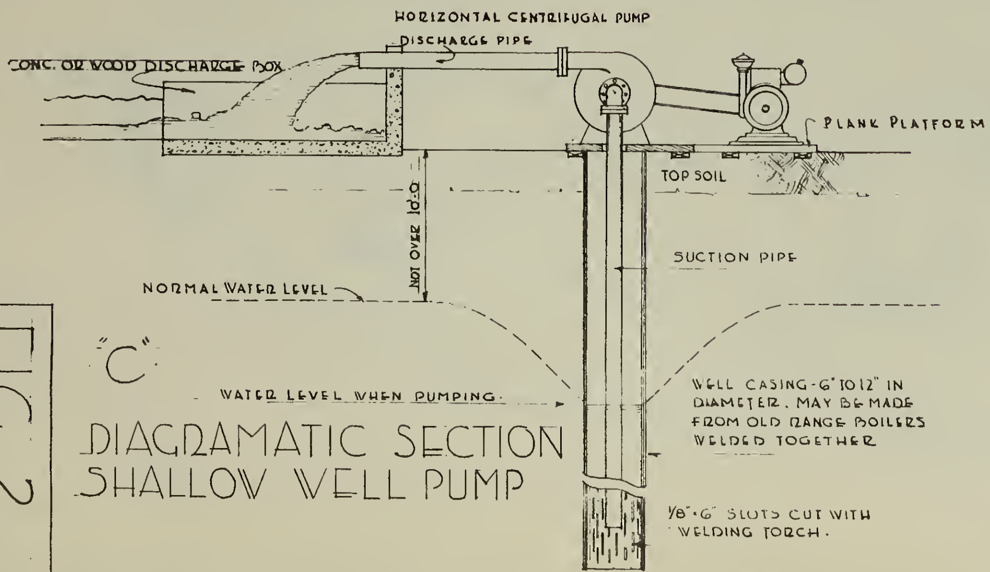
"A"

PUMPING SYSTEM FROM STREAM OR POND



"B"

DIAGRAMATIC SECTION OF PUMP SYSTEM FROM STREAM OR POND



"C"

DIAGRAMATIC SECTION SHALLOW WELL PUMP

FIG. 2.

PUMPING FROM A STREAM OR POND

GARDEN IRRIGATION CAN BE ACCOMPLISHED BY PUMPING FROM PONDS AND STREAMS IF THE LIFT IS NOT TOO GREAT. A SMALL HORIZONTAL CENTRIFUGAL PUMP SET NOT HIGHER THAN 10 FEET ABOVE THE WATER AND POWERED BY A GASOLINE ENGINE IS THE EQUIPMENT ORDINARILY USED. PUMPS OF THIS TYPE MAY BE HAD IN SIZES WHICH WILL DELIVER FROM 30 TO 1000 GALLONS OR MORE PER MINUTE.

PUMPING FROM SHALLOW IRRIGATION WELLS

ALONG RIVER BOTTOMS WHERE THE GROUND WATER LEVEL IS PERMANENTLY WITHIN 10 FEET OR LESS FROM THE SURFACE, SMALL IRRIGATION WELLS MAY BE SUCCESSFULLY USED FOR THE IRRIGATION OF FARM GARDENS. CASINGS FOR SUCH WELLS ARE ORDINARILY MADE FROM SHEET METAL SLOTTED TO PERMIT WATER TO ENTER. IN SOME INSTANCES OLD RANGE BOILERS WITH THE ENDS CUT OUT ARE WELDED TOGETHER AND SLOTTED WITH A WELDING TORCH. SMALL CENTRIFUGAL PUMPS SET AT THE GROUND SURFACE ARE QUITE SATISFACTORY.

USDA	FARM SECURITY ADMINISTRATION		USDA
DENVER COLORADO	IRRIGATION STRUCTURES		F. 313:10 D. 12/16/42
Des. WOOD	Dr. MOORE	Tr. MOORE	Ck.

"A" DIAGRAMATIC HYDRAULIC RAM LAYOUT

USE OF A HYDRAULIC RAM FOR GARDEN IRRIGATION

THE ACTION OF A HYDRAULIC RAM MAY BE EXPLAINED BY REFERENCE TO THE SKETCH AT THE LEFT. WATER FLOWS FROM THE SOURCE OF SUPPLY THRU THE DRIVE PIPE TO THE RAM. THE FALL IN THE DRIVE PIPE IS REPRESENTED BY "F" IN THE SKETCH. WHEN THE VELOCITY IN THE DRIVE PIPE BECOMES GREAT ENOUGH, A VALVE IN THE RAM SUDDENLY CLOSES, STOPPING THE FLOW IN THE DRIVE PIPE. THIS SUDDEN STOPPAGE OF FLOW CREATES CONSIDERABLE PRESSURE IN THE DRIVE PIPE AT THE RAM, WHICH FORCES A VALVE OPEN LEADING TO THE AIR CHAMBER AND ALLOWS SOME WATER TO ENTER. THIS PROCESS IS REPEATED AGAIN AND AGAIN UNTIL ENOUGH PRESSURE IS BUILT UP IN THE AIR CHAMBER TO FORCE WATER THRU THE DELIVERY PIPE TO SOME POINT AT AN ELEVATION "E" ABOVE THE RAM.

AN EXAMPLE OF RAM ACTION FOLLOWS:

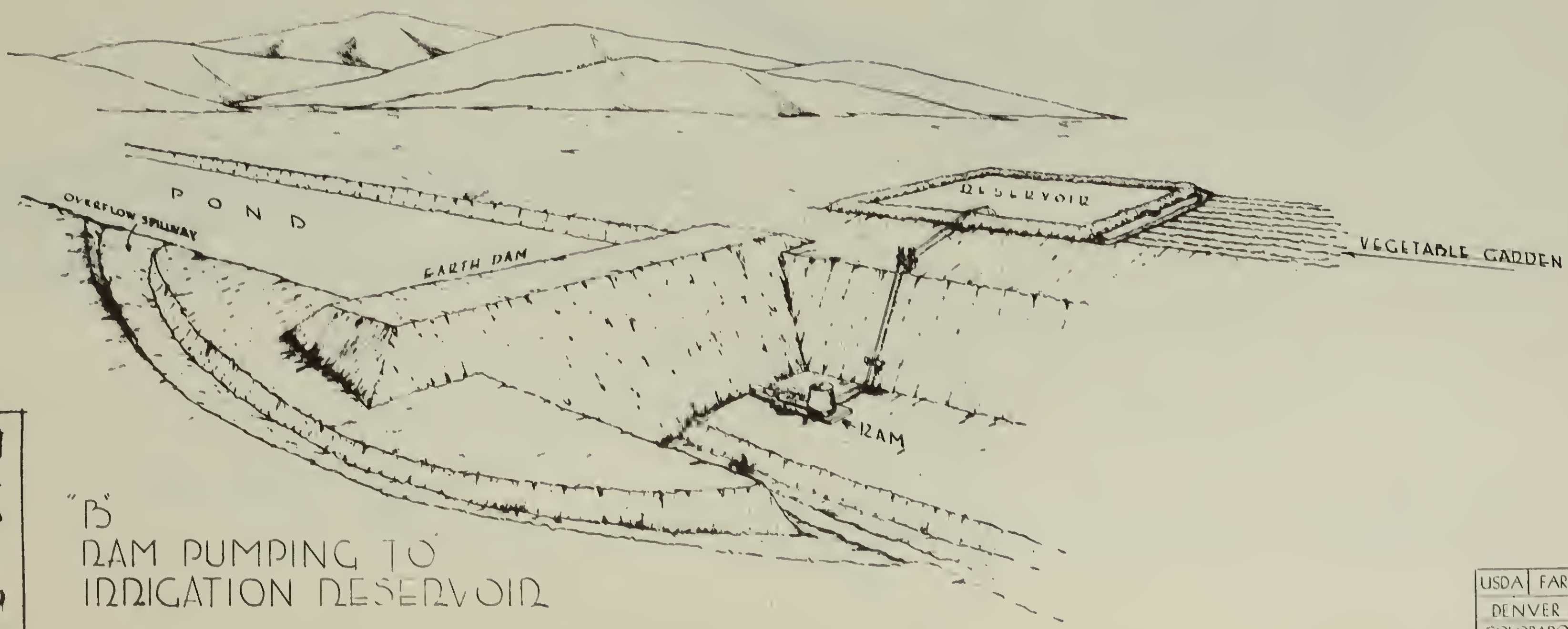
THE SUPPLY OF WATER AVAILABLE FOR THE DRIVE PIPE IS 30 GALLONS PER MINUTE. THE FALL "F" FROM THE SUPPLY TO THE RAM IS 15 FEET, AND THE LENGTH OF THE DRIVE PIPE IS 100 FEET. UNDER THESE CONDITIONS A RAM WOULD DELIVER 170 GALLONS PER HOUR TO AN ELEVATION "E" OF 100 FEET. FOR IRRIGATION PURPOSES RAMS WHICH WILL DELIVER FROM 150 TO 200 GALLONS PER HOUR ARE DESIRABLE.

AT "B" A RAM INSTALLATION IS SHOWN IN WHICH THE FARM POND IS THE SOURCE OF SUPPLY. SOMETIMES A LARGE SPRING CAN BE USED OR A STREAM CAN BE DAMMED FOR TEMPORARY USE IN SUMMER, DURING THE IRRIGATION SEASON. IF THE INSTALLATION OF A RAM IS CONTEMPLATED, MANUFACTURERS SHOULD BE CONTACTED RELATIVE TO SIZES, LENGTH OF DRIVE PIPE AND OTHER FACTORS. THE MANUFACTURER WILL NEED TO HAVE THE FOLLOWING INFORMATION:

FALL IN FEET FROM SOURCE OF SUPPLY TO RAM "F"

GALLONS OF WATER AVAILABLE AT SOURCE OF SUPPLY "V"

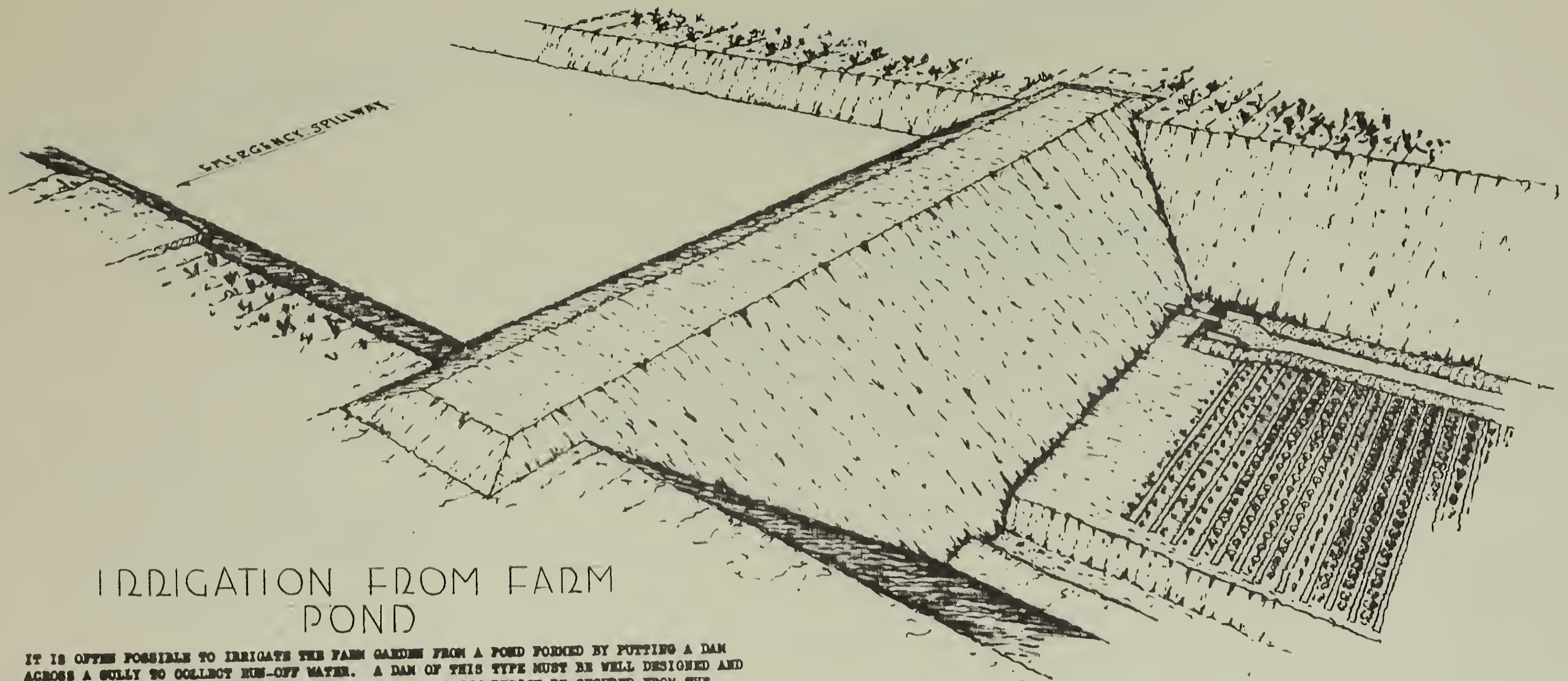
ELEVATION TO WHICH WATER IS TO BE DELIVERED "E"



"B"
RAM PUMPING TO
IRRIGATION RESERVOIR

FIG. 3.

USDA	FARM SECURITY ADMINISTRATION		USDA
DENVER COLORADO	IRRIGATION STRUCTURES		F.313:17 D.12/26/42
Des. WOOD	Dr. MOORE	Tr. MOORE	Ck.



IRRIGATION FROM FARM POND

IT IS OFTEN POSSIBLE TO IRRIGATE THE FARM GARDEN FROM A POND FORMED BY PUTTING A DAM ACROSS A GULLY TO COLLECT RUN-OFF WATER. A DAM OF THIS TYPE MUST BE WELL DESIGNED AND CONSTRUCTED. IT IS SUGGESTED THAT HELP RELATIVE TO THE DESIGN BE SECURED FROM THE LOCAL FARM SECURITY R.R. SUPERVISOR, THE COUNTY EXTENSION AGENT, OR ENGINEERS OF THE NEAREST SOIL CONSERVATION DISTRICT HEADQUARTERS.

PONDS OF THIS TYPE ARE USUALLY NOT SUCCESSFUL WHERE THE RUN-OFF IS COLLECTED FROM CULTIVATED LAND SINCE THE STORAGE SPACE ABOVE THE DAM SOON FILLS WITH SILT.

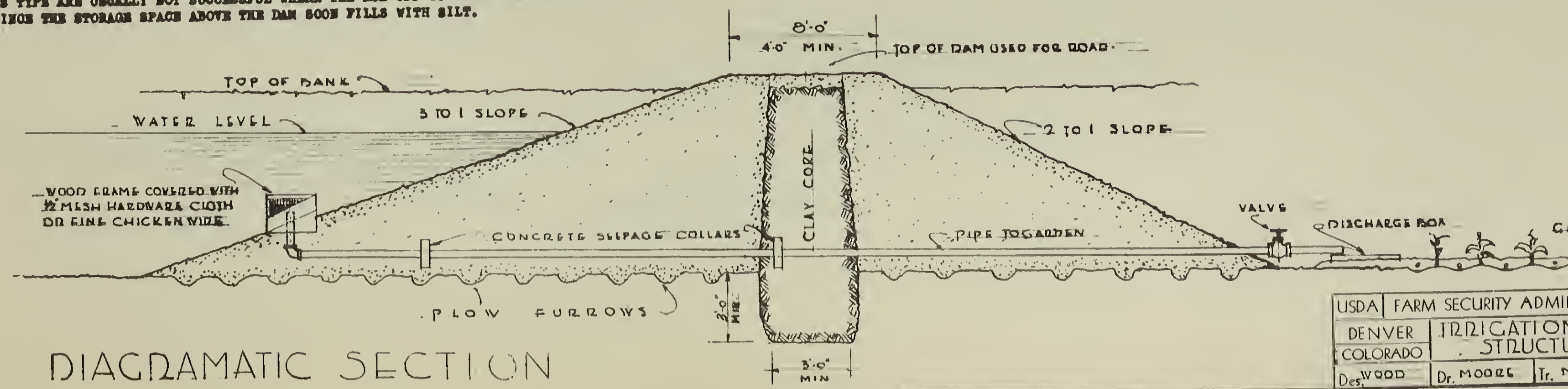
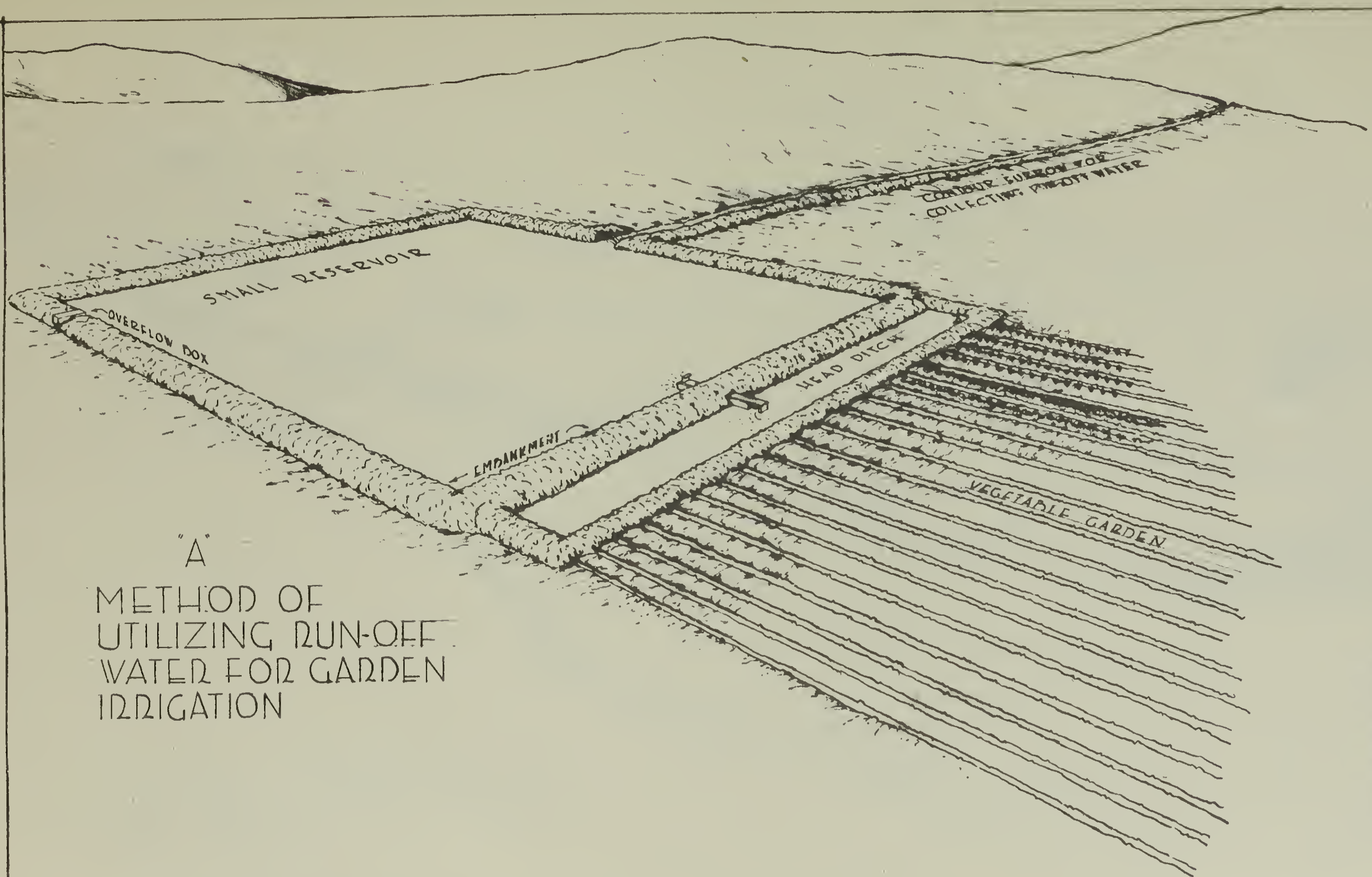


FIG. 4.

DIAGRAMATIC SECTION

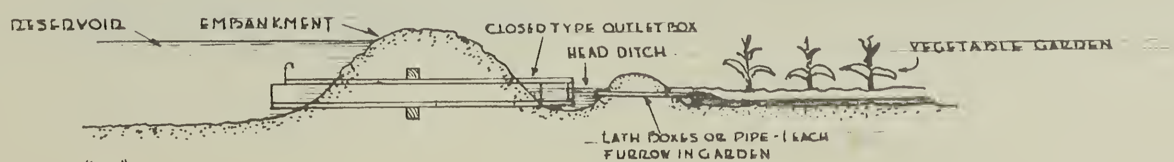
USDA	FARM SECURITY ADMINISTRATION		USDA
DENVER COLORADO	IRRIGATION STRUCTURES		F. 315-12 / D. 12/18/47
Des. WOOD	Dr. MOORE	Tr. MOORE	Ck.



"A"

METHOD OF UTILIZING RUN-OFF WATER FOR GARDEN IRRIGATION

MUCH OF THE RAILFALL OF THE ARID AND SEMI-ARID WEST COMES IN SHOWERS WHICH ARE INSUFFICIENT TO REPLENISH THE SOIL MOISTURE, DUE TO LOSSES FROM RUN-OFF AND EVAPORATION. USE OF RUN-OFF WATER MAY BE MADE BY COLLECTING IT IN A CONTOUR FURROW AND CONDUCTING IT TO A SMALL RESERVOIR AT THE UPPER END OF THE GARDEN WHERE IT MAY BE USED IMMEDIATELY. DUE TO HEAVY PERCOLATION LOSSES, NO ATTEMPT SHOULD BE MADE TO STORE WATER IN THE SMALL RESERVOIR FOR MORE THAN A FEW HOURS.

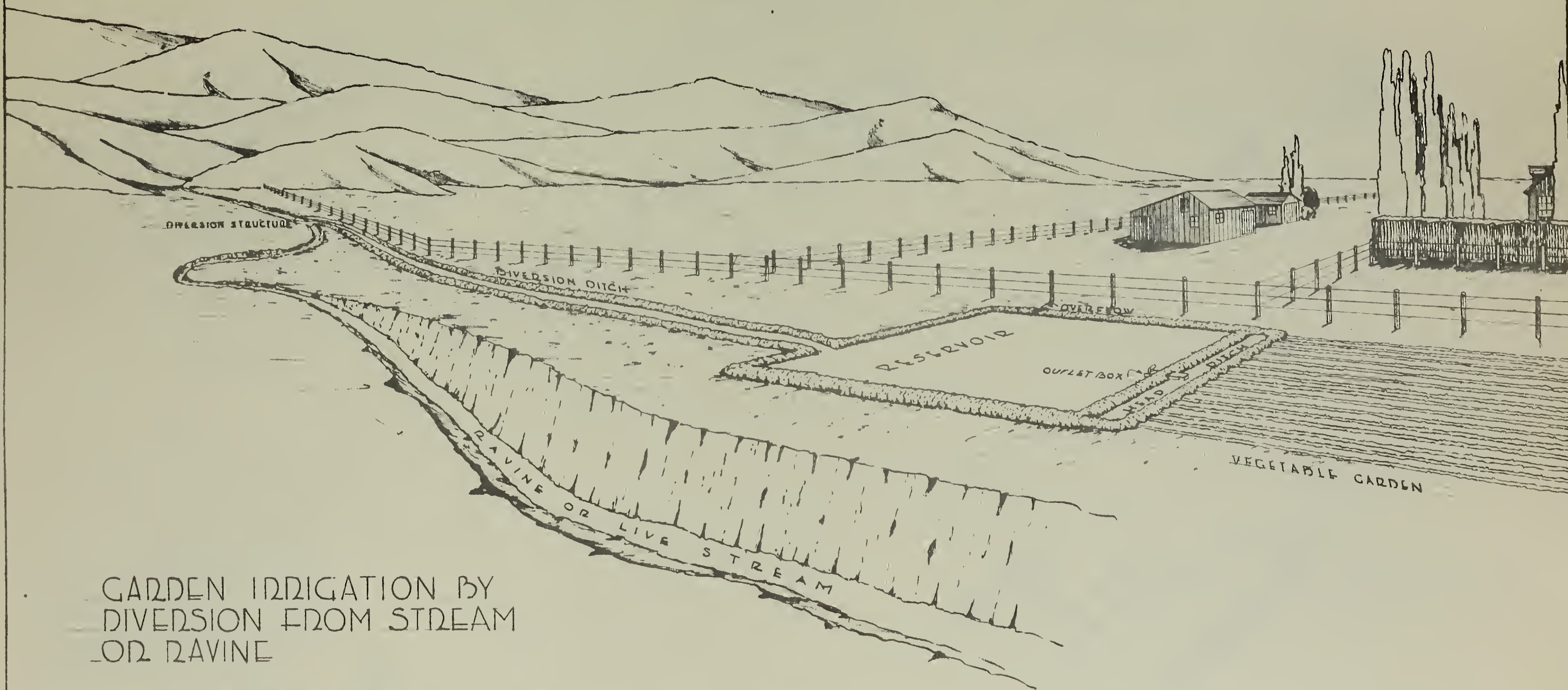


"B"

DIAGRAMATIC SECTION AT HEAD DITCH

FIG. 5.

USDA	FARM SECURITY ADMINISTRATION		USDA
DENVER COLORADO	IRRIGATION STRUCTURES		F.313:13 D.12/21/42
Des. WOOD	Dr. MOORE	Tr. MOORE	Ck.

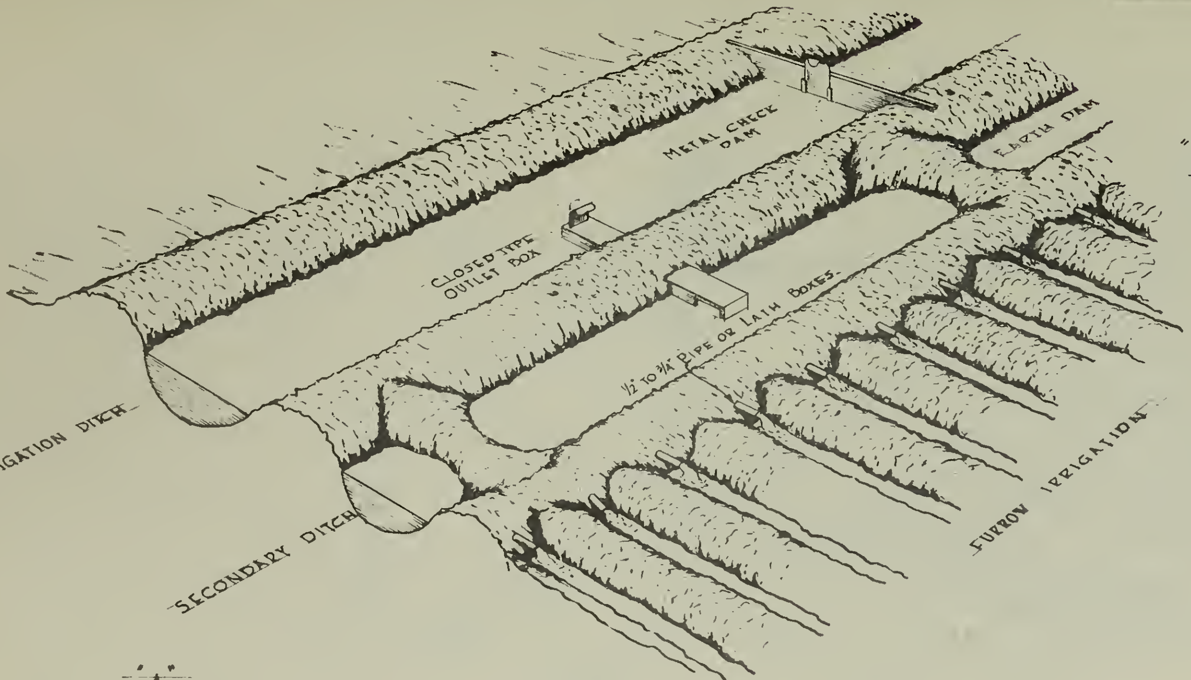


GARDEN IRRIGATION BY DIVERSION FROM STREAM OR RAVINE

THE DIVERSION OF WATER FROM A STREAM OR RAVINE IS OFTEN SUCCESSFUL FOR THE IRRIGATION OF A FARM GARDEN. THE AMOUNT OF RUN-OFF WATER DIVERTED MAY BE CONTROLLED BY THE SIZE OF DIVERSION DITCH USED, OR BY THE TYPE OF DIVERSION STRUCTURE. BETTER RESULTS WILL BE HAD IF A SMALL STORAGE RESERVOIR IS PROVIDED TO PERMIT BETTER DISTRIBUTION AND CONTROL OF THE HEAD OF WATER USED.

FIG. 6.

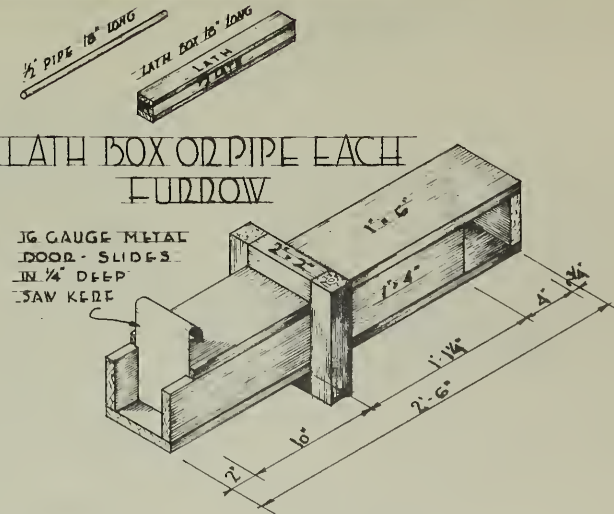
USDA	FARM SECURITY ADMINISTRATION		USDA
DENVER COLORADO	IRRIGATION STRUCTURES		F. 313:15 D. 12/22/42
Des. WOOD	Dr. MOORE	Tr. MOORE	Ck.



"A"

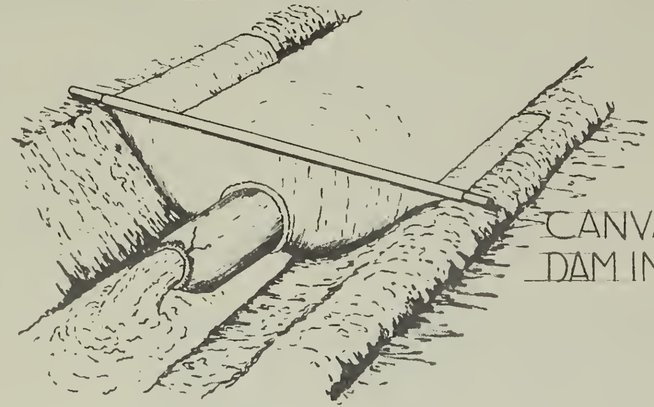
FURROW METHOD OF GARDEN IRRIGATION

WHERE WATER FOR IRRIGATION OF THE FARM GARDEN IS ABUNDANT, THE USE OF A HEAD DITCH AND A SECONDARY DITCH IS RECOMMENDED. THE HEAD DITCH IS CHECKED BY MEANS OF A METAL OR CANVAS DAM, AFTER WHICH WATER IS CONDUCTED TO THE SECONDARY DITCH THRU AN OUTLET BOX. FROM THE SECONDARY DITCH, WATER IS DISTRIBUTED TO EACH ROW THRU PIPES OR LATH BOXES SET IN THE DITCH BANK. THIS METHOD PERMITS OF ACCURATE DISTRIBUTION AND ALLOWS VERY CLOSE CONTROL OF THE HEAD TO EACH ROW.

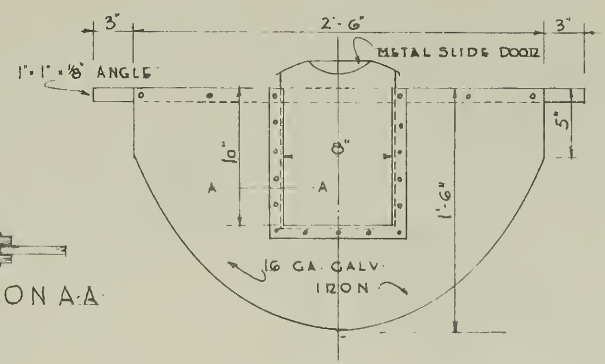


"B" LATH BOX OR PIPE EACH FURROW

"C" CLOSED TYPE OUTLET BOX

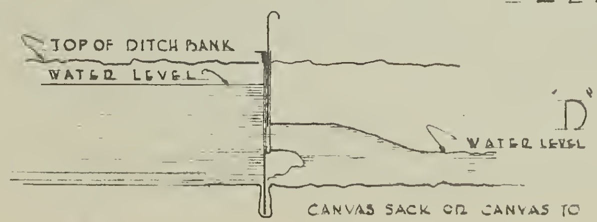


CANVAS CHECK DAM IN PLACE



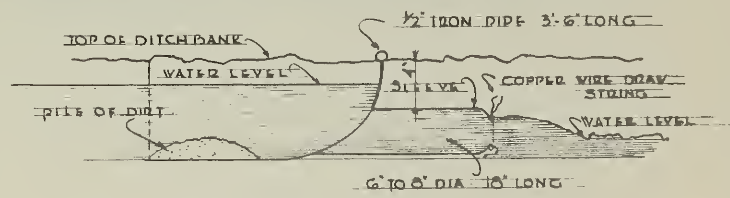
SECTION A-A

ELEVATION



SECTION

"D" METAL CHECK DAM

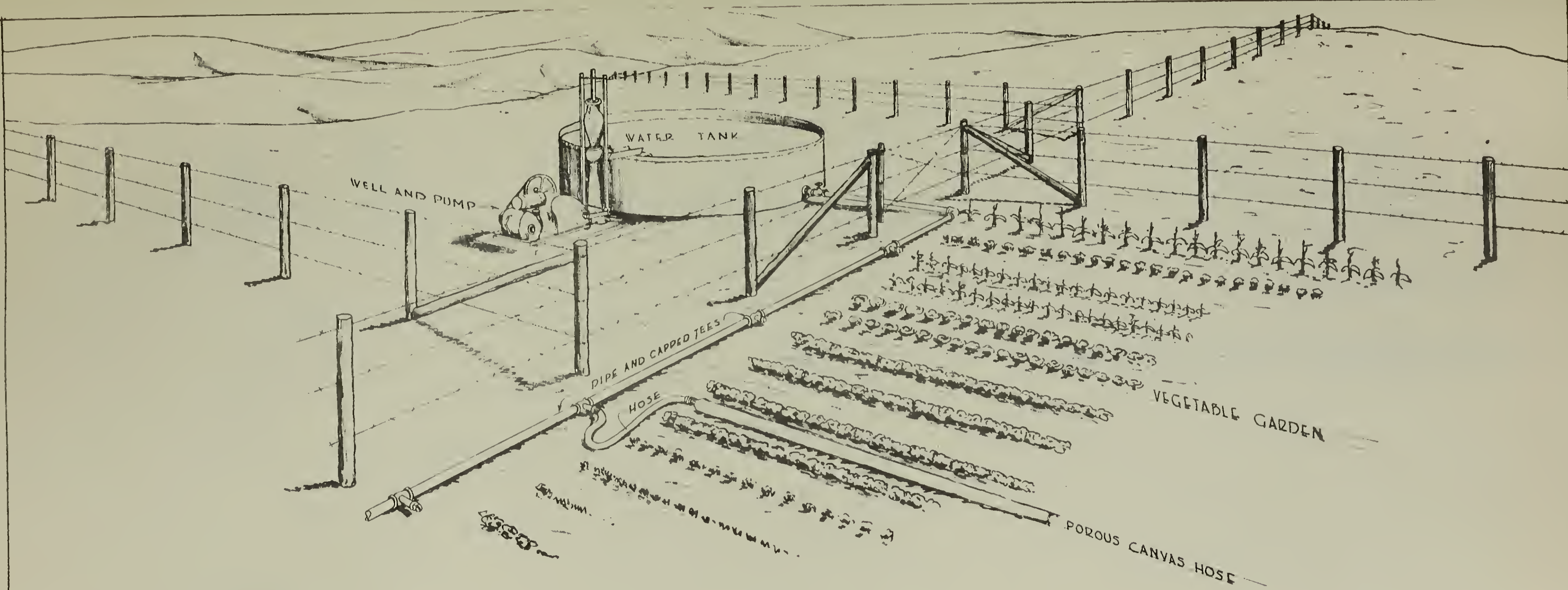


"E" CANVAS CHECK DAM

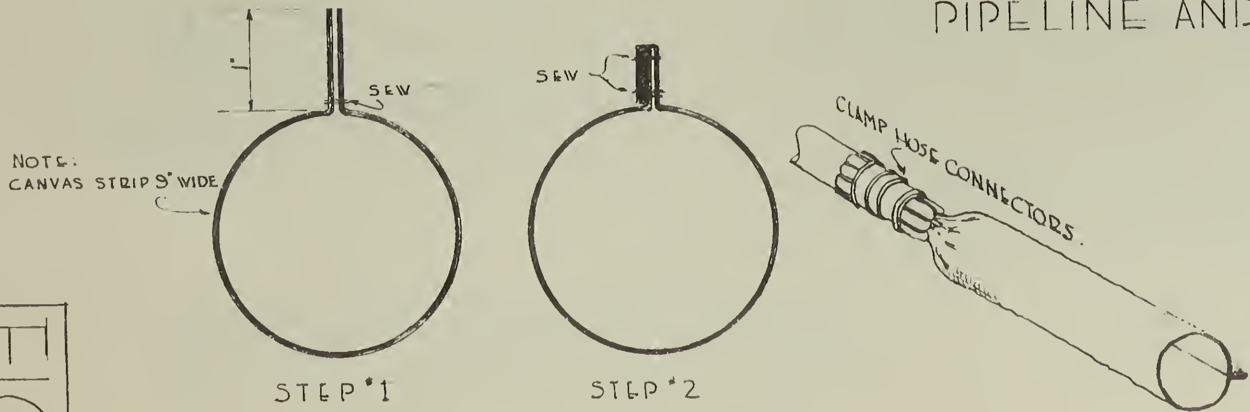
THE CANVAS CHECK DAM IS SOMETIMES USED INSTEAD OF THE METAL ONE BECAUSE IT IS EASIER TO MAKE AND IS EASIER TO KEEP IN PLACE IN SANDY SOILS. WHEN PROVIDED WITH A BOOT FITTED WITH A DRAW STRING, THE FLOW PAST THE DAM CAN BE CONTROLLED.

USDA	FARM SECURITY ADMINISTRATION		USDA
DENVER COLORADO	IRRIGATION STRUCTURES		F. 313 - II D. 12/17/42
Des. WOOD	Dr. MOORE	Tr. MOORE	Ck.

FIG. 7.



"A" GARDEN IRRIGATION FROM PIPELINE AND CANVAS HOSE

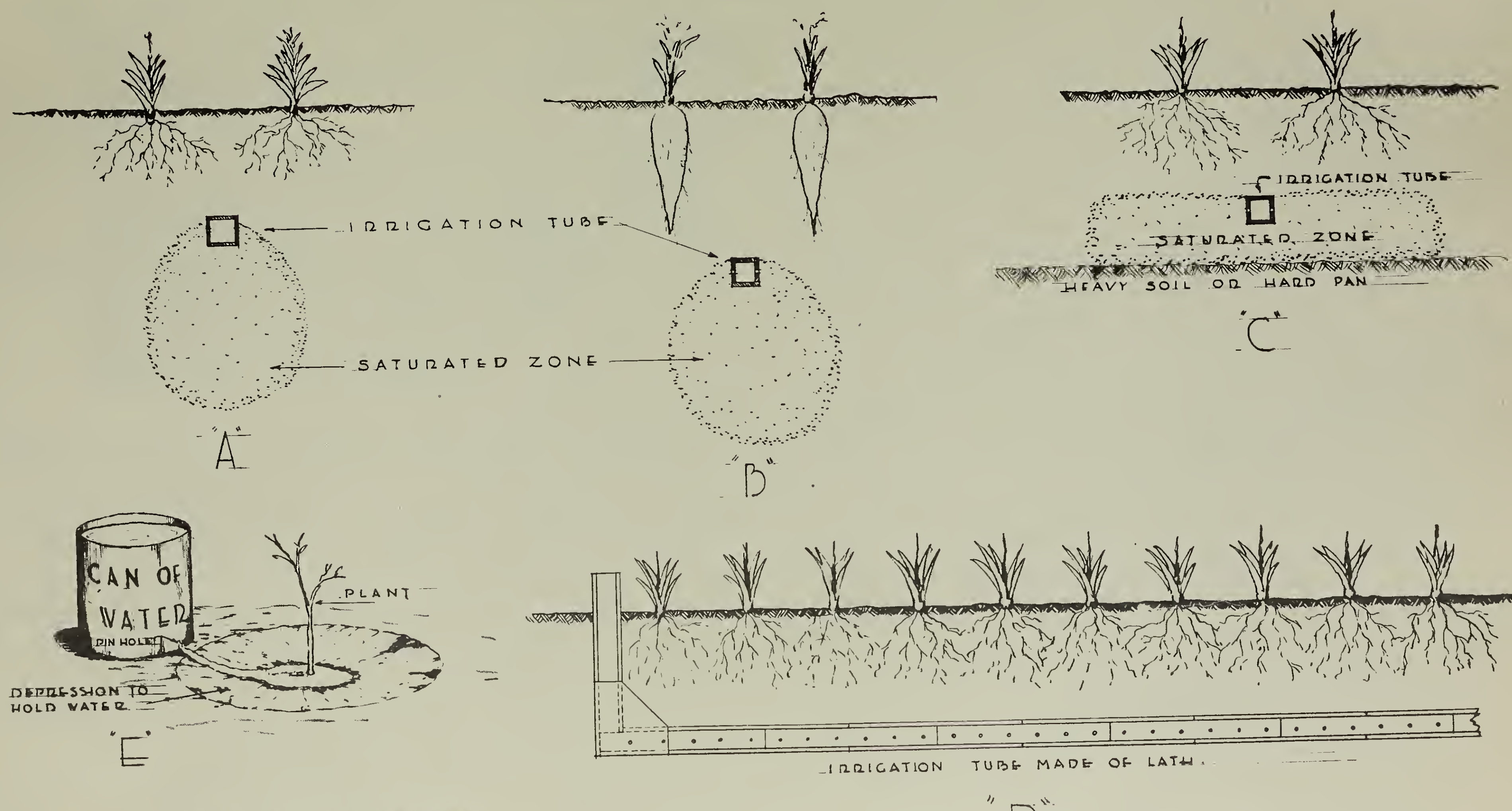


"B" CANVAS HOSE DETAILS

FOR MANY CONDITIONS CANVAS OR DENIM HOSE MAY BE USED SUCCESSFULLY FOR GARDEN IRRIGATION. WATER UNDER SLIGHT PRESSURE IS CONDUCTED TO THE GARDEN THRU PIPE OR RUBBER HOSE WHERE THE CANVAS HOSE IS CONNECTED AND LAID IN POSITION NEAR THE GROWING PLANTS. WATER SEEPS THRU THE PORES IN THE CLOTH AND ENTERS THE GROUND WITHOUT MUCH LOSS FROM EVAPORATION OR RUN-OFF. THE HOSE IS MOVED ABOUT FROM PLACE TO PLACE AS THE GROUND BECOMES SATURATED.

USDA	FARM SECURITY ADMINISTRATION		USDA
DENVER COLORADO	IRRIGATION STRUCTURES		F.313: D.12/23/42
Des. WOOD	Dr. MOORE	Tr. MOORE	Ch.

FIG. 8.



"D"

SUB-SURFACE IRRIGATION BY MEANS OF TUBES

THE IRRIGATION OF GARDENS BY MEANS OF TUBES LAID UNDER GROUND IS NOT ALWAYS SUCCESSFUL DUE TO THE FACT THAT WATER SEEPING FROM THE TUBE INTO THE SOIL HAS A TENDENCY TO SATURATE A ZONE WHICH RANGES DOWNWARD AWAY FROM THE PLANT ROOTS. IF THE SOIL IS UNDERLAID WITH "HARD-PAN" WHICH IS DIFFICULT FOR WATER TO PENETRATE, THE SATURATED ZONE MAY SPREAD TO THE PLANT ROOTS.

TUBES MADE OF LATH NAILED TOGETHER AND DRILLED TO PERMIT WATER TO ESCAPE ARE MORE SUCCESSFUL THAN TIN CANS OR OTHER MAKE-SHIFT TYPES. THE LATH MAY BE TREATED BY SOAKING THEM IN CREOSOTE OR CRANK-CASE OIL DRAINED FROM CARS.

USDA	FARM SECURITY ADMINISTRATION		USDA
DENVER COLORADO	IRRIGATION STRUCTURES		F.313:16 D.12/24/42
Des. WOOD	Dr. MOORE	Tr. MOORE	Ck.

FIG. 9.

TIME REQUIRED TO SUPPLY VARIOUS QUANTITIES OF WATER TO VARIOUS SIZED GARDEN TRACTS

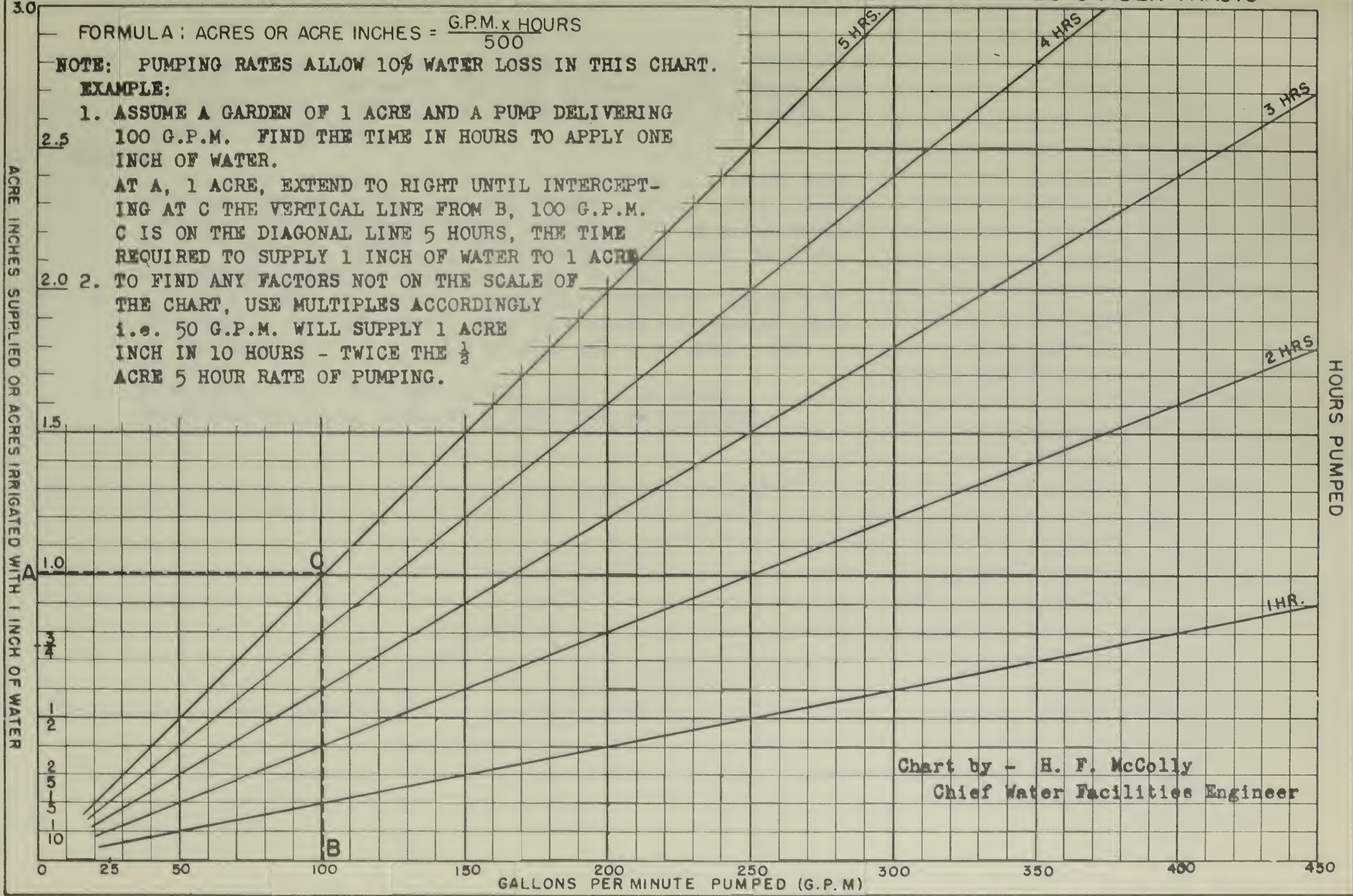


FIG.10

TIME REQUIRED TO SUPPLY VARIOUS QUANTITIES OF WATER TO VARIOUS SIZED GARDEN TRACTS

FORMULA: ACRES OR ACRE INCHES = $\frac{\text{G.P.M.} \times \text{HOURS}}{500}$

NOTE: PUMPING RATES ALLOW 10% WATER LOSS IN THIS CHART. THIS CHART CAN BE USED TO DETERMINE THE TIME, ACREAGE, AND PUMPING RATE FOR EITHER TANK STORAGE FOR GARDEN IRRIGATION, OR DIRECT PUMPING TO THE TRACT.

EXAMPLES:

1. TO IRRIGATE A GARDEN PLOT OF 1/5 (0.20) ACRE IN 8 HOURS TIME REQUIRES PUMPING 12½ GALLONS PER MINUTE. AT A, 1/5 A., EXTEND TO RIGHT UNTIL INTERCEPTING THE DIAGONAL LINE "8 HOURS PUMPED" AT B. THEN DROP VERTICALLY TO THE HORIZONTAL LINE "GALLONS PER MINUTE PUMPED" AT C WHICH IS 12.5 G.P.M.
2. A 3 G.P.M. PUMP WILL HAVE TO OPERATE 32 HOURS TO SUPPLY 1/5 ACRE WITH 1 INCH OF WATER. THIS IS 4 TIMES THE AMOUNT SHOWN ON THE CHART FOR 3 G.P.M. AT 8 HOURS AND 0.05 ACRE. SEE POINT D.
3. A 25 G.P.M. PUMP WILL PUMP 1 ACRE INCH IN 20 HOURS. TWICE THE 25 G.P.M. RATE FOR ½ ACRE INCH IN 10 HOURS

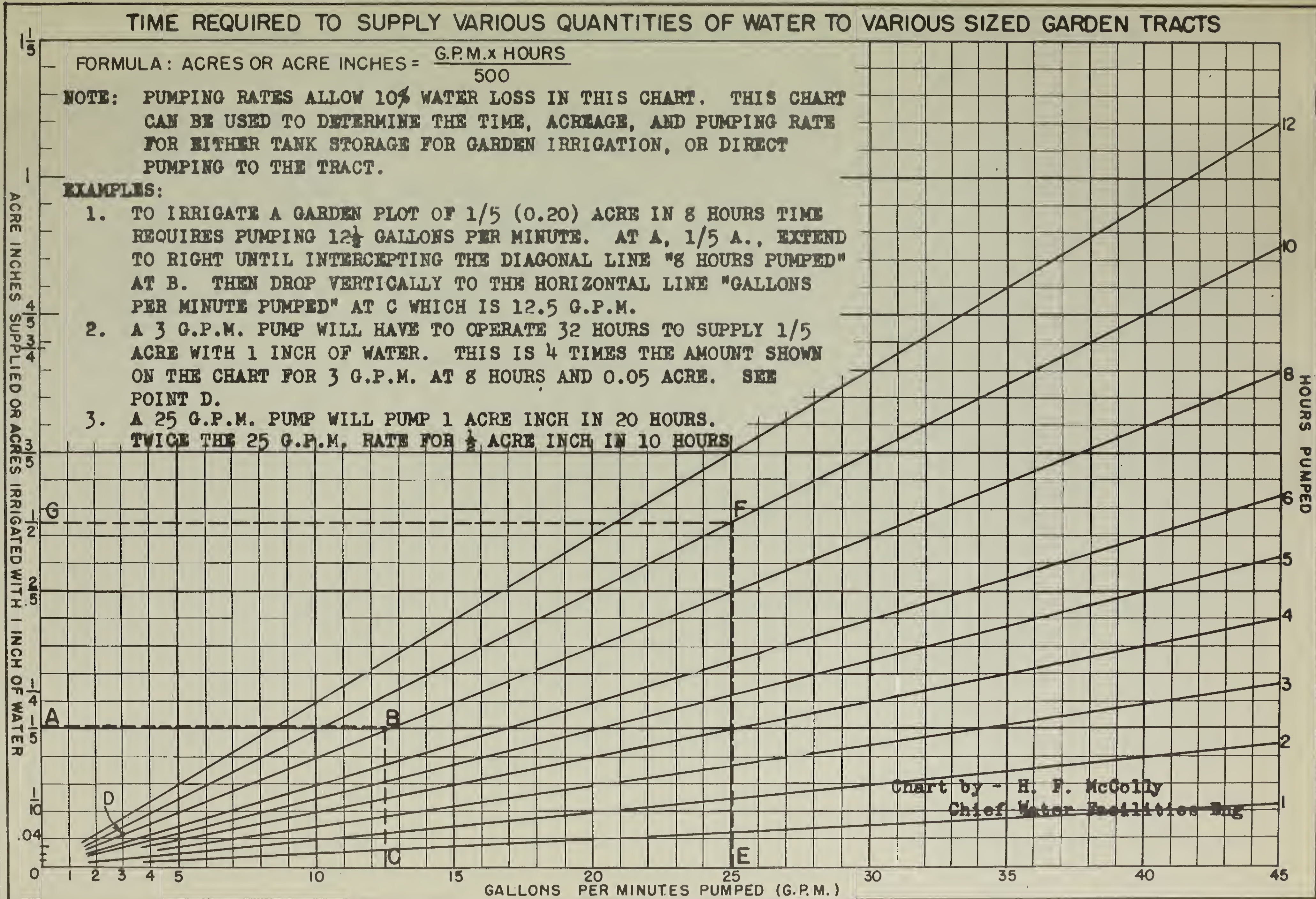


FIG. 11

HORSEPOWER REQUIRED FOR PUMPING WATER AT APPROX. 50% OVERALL PUMPING PLANT EFFICIENCY

FORMULA: $H.P. = \dfrac{G.P.M \times Head}{3960 \times 50.5\%}$

EXAMPLES:

1. A 1 H.P. ENGINE IS AVAILABLE FOR PUMPING AND THE HEAD IS 20 FT. FIND HOW MANY GALLONS OF WATER CAN BE PUMPED PER MINUTE.
   AT A, 1 H.P., EXTEND TO THE RIGHT UNTIL INTERCEPTING THE DIAGONAL LINE 20 FT. AT B. FROM B DROP DOWNWARD TO THE HORIZONTAL LINE G.P.M. AT C. 100 G.P.M. WILL BE PUMPED.
2. PUMPING 50 G.P.M. AGAINST A 10 FT. HEAD WILL REQUIRE ABOUT ¼ H.P. SEE POINTS D, E, F.

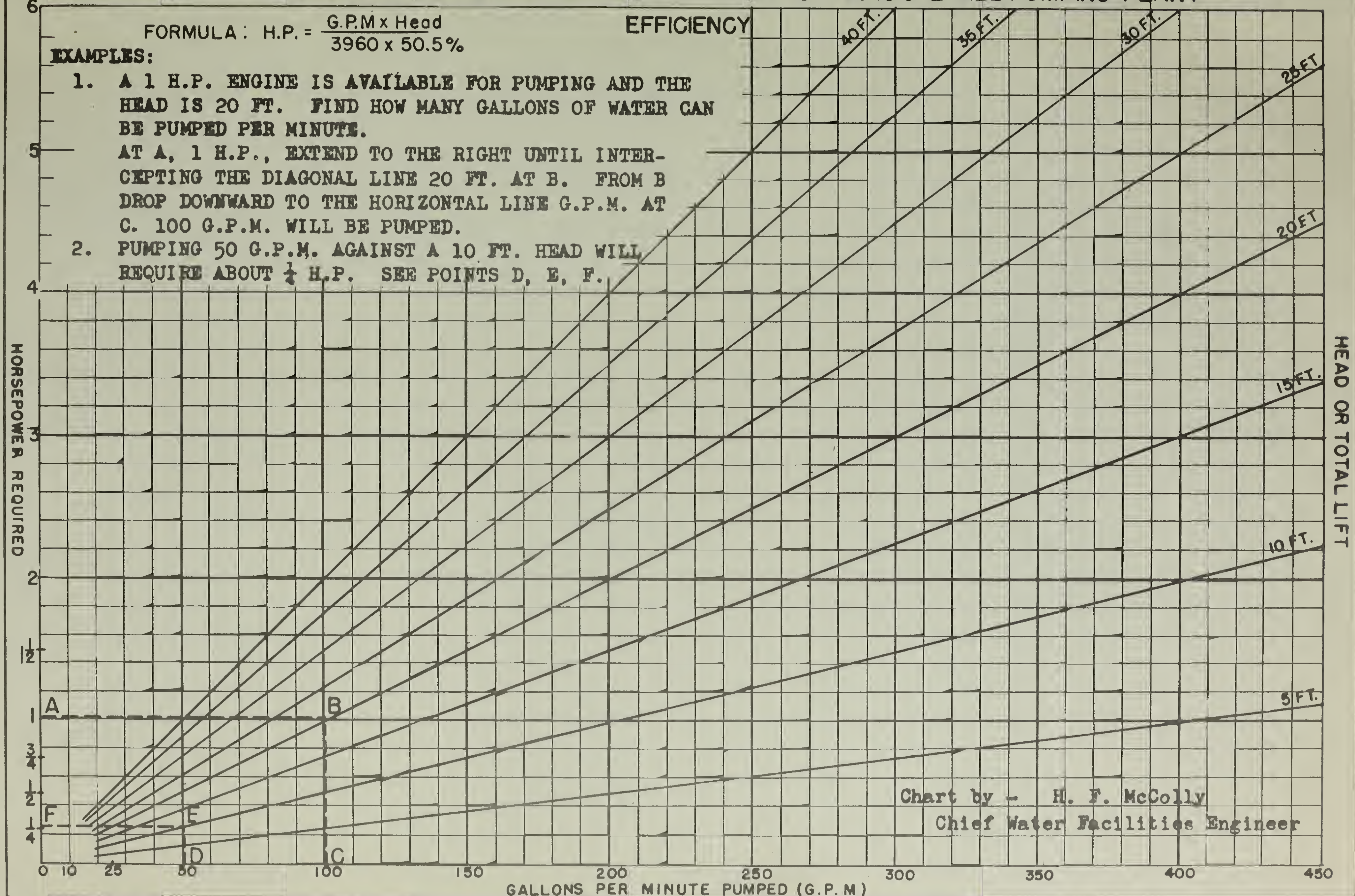


FIG. 12